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The Time of Some Mental Processes
in the Retardation and Excitement
of Insanity

BY

SHEPHERD IVORY FRANZ

(From the Laboratory of Pathological Physiology of the McLean
Hospital, Waverley, Mass.)

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(From the Laboratory of Pathological Physiology of the McLean Hospital, Waverley, Mass.)

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Introduction. The present work was undertaken in order to gather material for the solution of the problem: to what part or parts of the nervous system may we refer the increased and the decreased psychomotor activity usually found in depressed-maniacal insanity.

The earlier psychiatrists considered as separate disease entities abnormal emotional depressions and exaltations, under the names of melancholia and mania, and the condition in which there is a more or less regular alternation of the exaltation and the depression, called circular insanity. The last state was deemed very peculiar, but until the time of Kraepelin it seemed not to have been closely associated with either of the two other conditions. To Kraepelin is due the credit for having shown that circular insanity, mania and melancholia (in its simple form) are interrelated and belong to one group which he termed *Manisch-depressive Irresein*.¹ Hoch has well summed up the main points of the present condition (according to the Kraepelinian school) of the combination of mania, melancholia and the older circular insanity;² a tendency to recurrence, the absence of mental deterioration, psychomotor excitability or re-

¹ This name has been variously translated, the most common being "manic-depressive insanity." See Hoch's article in Wood's *Handbook of the Medical Sciences*, Vol. V, "Manic Depressive Insanity," Paton's recent book: *Psychiatry*, and de Fursac, *Manual of Psychiatry*, Trans. by Rosanoff. This designation is a transliteration of the German, regardless of English meaning and spelling; the word *manic* is not given in the Century Dictionary and the word *depressive* means "able or tending to depress." It is not the insanity which is depressive but the depression is the "insanity."

² *Op. cit.*

tardation, emotional exhilaration or depression, and difficulty or (apparent) ease in thinking. These alternative symptoms may be variously combined in individual cases, the most usual, however, being the combinations of (a) exhilaration+excitability+flight of ideas and (b) depression+retardation+difficulty in thinking. In the excited phase of this condition the emotional tone is exalted. There is a feeling of *bien aise*, of expansiveness, of great ability, and of self-satisfaction. There is more or less motor excitement and a seeming rapidity of associations, with flight of ideas. The associations are usually superficial and sound associations. The attention is very unstable. In the depressed phase there is a lowering of emotional tone, and a feeling of *malaise*, of hopelessness, perhaps of fear, and there may be suicidal tendencies and attempts. There is often a profound motor disturbance in which the reactions—using that word in its widest sense—are slowed, and an appearance of decrease in associative ability; in other words a retardation. Any of these symptoms, but of course not opposites, may be present to a mild or to a most marked degree.

The differences in motor activity of this class of the insane have been studied to some extent¹ but so far as I am aware there is no published account of work such as is here attempted. At the present writing there is available only an incomplete skeleton of the work necessary for a full understanding of these motor conditions. The present article is, however, complete in itself and is to be considered as part of the general plan.

Clinical Histories of the Subjects. Six subjects were chiefly used in the research, two normal, two depressed (retarded), and two exhilarated (excited), as follows:

Normal subjects. F., the writer, upon whom the whole series could not be made, was used as one normal subject. The other normal subject was B., a business man, age 49 at the time the experiments were being made, had been a patient at the hospital for about seven years. During the course of the experiments B. was considered 'recovered,' and had been practically so for about a year. He was admitted² to the hospital Oct. 22, 1897.³ He had previously indulged quite freely in alcoholic liquors, but for over a year had very little alcohol. For ten months before admission the patient had appeared not

¹ Especially reaction times: W. Bevan Lewis, *Textbook of Mental Diseases*, 2d edit., London, 1899, pp. 164, 364 and 365. Richet: *Dictionnaire de Physiologie*, Article Cerveau, Vol. III, p. 29. v. Tschisch: *Neurol. Centralblatt*, 1885, IV, p. 217. G. Lefmann: *Psychol. Arbeiten*, 1904, IV, 603-668. On fatigue: Hoch, *Journ. of Nervous and Mental Diseases*, 1904, XXVIII, 620-628.

² The clinical accounts have been copied from the hospital records. The notes were made chiefly by Drs. A. Hoch, Steele, Roberts and Hamilton.

so well, had become absent-minded, depressed, and later more inactive. On entrance he spoke slowly in a monotonous tone, expression immobile, rather blank, yet said he worried about everything. He was not clear as to where he was, and in the afternoon did not remember the physician whom he had seen for a short time on entrance (morning). Later he was oriented as to time, place and persons, did not occupy himself, did not speak spontaneously, but answered calculation questions, even difficult ones, very promptly, but questions regarding his condition were answered by "I don't know." There was no memory difficulty. In four months he became a little more spontaneous, and his sentences were a little longer when he talked. In the gymnastic class he was reported to make his movements promptly and well. For four years he remained practically stationary, answering slowly, doing little, but when made to do things, as in the gymnasium class, doing them promptly and well. "It is the fact that with a sufficient external stimulus the patient can act promptly while it seems that if he has to supply the stimulus himself there is so little activity that it makes his general condition appear rather the outcome of an apathy than of a retardation." In June, 1903, it was noted that "there has been a slow, gradual gain which from day to day or week to week, or even month to month has been imperceptible, but which on looking back has amounted to a very great transformation. The man shows now in regard to conversation and in regard to occupying himself with everything that is possible in the hospital a very decided spontaneity. He shows, moreover, good judgment in his conversation. He is one of the best billiard, tennis and whist players and is occupied all the time." He did not ask to be allowed to go home, did not think he could attend to his business, but when questioned in regard to his condition the old reply "I don't know" was sometimes given. During the following summer the patient was occupied most of the time playing golf, tennis, etc. There was a gradual improvement, although when anything out of the ordinary arose he was inclined to hesitate a little. During the succeeding year there was a gradual recovery and at the time of the laboratory experiments he was practically well, although disinclined to take up business. The patient was discharged May 29, 1905.

Retarded subjects. Ed., a hotel clerk, age 21, was admitted to the hospital May 8, 1904, greatly depressed and retarded. For some years previous to his attack of melancholia he had been troubled greatly with dyspepsia, and he had always been inclined to worry about his business and other affairs. In March, 1904, the patient could not attend to his work, gave up his position, and was greatly worried about himself. He would

say, as an example of his depressive ideas, "I am no good." When taken to drive he feared lest the horse was not strong enough to pull him, etc. At this time the patient was taken to his father's office and performed what little things were asked of him, *e.g.*, writing down orders and answering the telephone, but there was no spontaneity. Gradually he became slower in his movements, but in the beginning of May was restless and once made an attempt at suicide by drowning. After this he was even less active, refused food, and was untidy if not closely watched. He expressed the ideas that he was turning to stone, that his throat had been cut, that his feet had been taken off, that he had no tongue, and that his neck was broken. After his entrance to the hospital he remained in bed, lying perfectly quiet, seldom moving any part of his body. Upon repeated requests he did not show his tongue, although it was seen to move slightly in his mouth, which was partly open. There was no reaction to pin pricks. He was tube-fed. When requested he could be made to walk slowly to a chair and to sit down, but all movements made at command were done very slowly and often incompletely. It was impossible to get the patient to answer any questions. On most occasions he had to be moved by the nurses from place to place. On one or two occasions he was heard to say "What have I done?" "Where am I?" About three weeks later the patient obeyed simple commands such as 'Get out of bed,' 'Sit in the chair,' but all his movements were made slowly, and with a considerable interval between the command and the beginning of the movement. Common answers to questions, sometimes given quite promptly, were "No," "I don't know." He knew his name and age, and related part of his previous history slowly but well, but he did not know where he was, how he came to the hospital, or how long he had been here. He did not remember the physician although he had been tube-fed by him for twenty-three days, three times a day. A few days later he could not be made to give the date, place, etc., and answered to all questions "I don't know." At this time he was heard to remark, "I have no eyes, no arms, no legs." Three weeks later he knew the names of the nurses and of many of the patients on the ward, and not infrequently made remarks about the latter. His time was entirely unoccupied, and was spent walking slowly about the hall or in the yard, or sitting or lying about the hall or in his room. On June 2, he ate well three meals and from that time did not have to be tube-fed. Simple questions were now answered readily, but questions the answers to which required the least thought either received no response or "I don't know." July 30, there was considerable improvement over his previous condition. Occasionally, especially

towards evening, he walked about better, and talked more freely to the nurses and physicians. At times, however, all one could get from him was "I am suffering more than any one else in the world," or "I am all twisted," etc. On general subjects he often answered well but slowly, but so soon as his condition was touched upon, he would not answer. He was at this time perfectly clear regarding his surroundings, oriented as to time and place, and knew the people about him. On August 24th, when the series of experiments were begun, the patient was in the condition just described. He answered slowly and in whispers and it took considerable persuasion and often commanding to get him to start upon the work. A month later, September 26, it was noted that there had been a steady improvement in the patient's condition. He took part in games, and made a fairly natural general impression. He played pool and billiards well. For about three weeks he had not talked so much of being "abused" and of being "the sickest man in the world," and these ideas had been gradually disappearing. The period of his convalescence seemed to be very short; he seemed to get well by leaps and bounds. The experiments were continued from August 24 until his discharge "recovered" Nov. 9, 1904.

Ev., the other retarded subject, was at the time of the experiments 65 years old. He was a business man, admitted to the hospital Oct. 15, 1903. In temperament he was inclined to be optimistic. He was social and entertaining, but rather easily irritated. Previous to his present illness he had had six attacks of depression. All of these had been rather typical, showing depression, a feeling of inadequacy, and some retardation. These attacks came respectively at the following ages: 22, 30, 37, 44, 51, and 58. The later ones lasted about six months, and the course was very similar in all. Each started with a depression, and a gradual quieting and inactivity. Then he took little interest in things about him, was depressed about everything, thinking that his business was 'going to the bad' and that his family would be ruined. At these times there was considerable self-reproach, etc. He always spoke in a low tone and answered slowly. The attacks usually wore off quite gradually, with an improvement in his physical condition and a relief from his insomnia, and he returned to his 'natural optimistic self.' During the past five years the patient had been under a mental strain because of business difficulties. The present illness began in December, 1902. He began to be depressed and to sleep poorly, but kept at his business until February, 1903, when the firm failed. He was 'completely exhausted' by the failure and remained in bed for a week during which time his condition was as follows: quiet, felt unable

to do things, had considerable self-reproach, took little interest in things about him, complained of feeling exhausted and weak. Then he became restless and agitated and would not eat. He was sent to an insane hospital in a neighboring city, his restlessness disappeared and gave place to a retardation. He remained quiet for the most of the time, sat in one place, and had to be urged to do things. He was mentally clear, and well oriented. On entrance to McLean Hospital, October, 1903, the patient answered questions very slowly—five to eight seconds—looked quite depressed, obeyed commands slowly, walked quite hesitatingly, protruded the tongue barely beyond the lips. He sat about unoccupied, without any spontaneous talk, almost with no movement. He showed, in fact, a very typical psychomotor retardation. He is senile physically, but not mentally. The condition of the patient remained stable. He was always quiet, saying and doing nothing except an occasional mumbled answer in a tone so low as to be scarcely audible. His time was occupied in standing quietly or sitting in one place, occasionally looking around him. He occasionally answered questions briefly, slowly, and in a very low tone. When told to go to the dining room he went very slowly, but was able to find his own seat. He ate in a normal manner, using knife, fork and spoon properly, and at the proper times. At night he would not undress himself, and in the morning would not get up until taken out of bed by the nurse. He ate and slept well. During the next few months the patient gradually improved in that he took more notice of things about him, moved a little more quickly, and more often. He looked after his wants better, and was a little more independent, *e. g.*, he would go to the dining room when the bell was rung. From that time the condition remained almost stable. He sat about the ward, always unoccupied, very depressed, never talked to any one except to answer questions. He was distinctly retarded except in the matter of eating, which he did as rapidly as any one. He dressed and undressed himself slowly. He was perfectly oriented as to time and place, and knew the people about him. There seemed to be no memory defect and no thinking disorder. The following is a note made August 29, 1905: "Very little change has been noted in the patient's condition. He is always seen sitting dejected and inactive in the sitting room, and if asked to shake hands he extends his right hand very slowly forward. In answering a question he hesitates for some time, and finally whispers out a reply. This observation applies to his conduct on the ward, where his retardation is marked. About two weeks ago he was taken to the laboratory for four days to be put through a number of tests. One of these tests required him to read

aloud, which he did quite audibly on the third day. . . . Other tests were responded to in such a manner as to indicate that he not only understood all that was said to him, but that he could do various things calling for a considerable exercise of his power of attention, recognition and discrimination. Once an experiment was explained to him, he co-operated intelligently, and although with considerable retardation, quite accurately. . . . His memory is good, as is also his orientation as to time and place. Depressive ideas remain, as for example, his usual answer to questions concerning his health: "No better—I shall never be any better." (Hamilton.) This patient took part in the experiments reported in this paper from August to December, 1904, and again in August, 1905. He was discharged to go to another hospital Oct. 8, 1905, in the condition that had been characteristic of him for the past year.

Excited Subjects. C., age 48, a mechanic, of fair education, with a fourth attack of insanity, was admitted as a patient to the hospital August 2, 1904. The first attack (March 8 to May 21, 1901) was a depression. The patient had been a heavy drinker and six years before entrance, in 1901, he had taken the Keeley cure. After that he did not drink until a short time before his admission. In the previous summer C. was very irritable and inclined to worry over small matters. Then he lost interest in his work. Four months before admission he stopped work, and thought his friends were against him, avoided them, became morose and remained at home. His memory at that time was not good, he slept poorly, but there was no marked depression. When admitted (March, 1901) the patient said that he stopped work because he could not attend to it and "got balled up." He had difficulty in thinking. Multiplications that required much thinking were difficult and almost impossible. He said spontaneously that his memory was poor and objectively it was shown to be so. Things which he knew well, *e.g.*, when he came to the hospital, when he last saw the physician, etc., took him a long time to think out. He worried because he could not do his work. During the succeeding two and one-half months he improved rapidly, felt able to take up his work again, and said that his memory was good again. His second attack was an excitement (December 4, 1901, to March 18, 1902). After leaving the hospital in May he began to work, bought another business, worked hard, and showed good judgment in his affairs. In November he became exhilarated, and talkative, but not unduly expansive in his ideas. He also showed a certain forgetfulness. During his stay at the hospital he was decidedly euphoric and exhilarated. He showed a great deal

of over-activity. He talked much, decorated his room, and showed a distinct flight of ideas. Everything was said to be "fine;" the hospital "the finest place in the world," etc. He showed no memory defect at that time, but on the contrary had a good grasp on details of both present and past events. He gradually quieted down and became more normal and was discharged "much improved." For four months the patient worked well, but was a trifle irritable from time to time, and in the summer became quite tired. About three months before his third admission he began to have difficulty in applying himself to his work, and drank heavily. Afterwards he could not do his work, became seclusive and slept poorly. Readmitted in December, 1902, he was depressed until May, 1903 (third attack). In this attack he was more depressed than he had been in 1901. He said he was 'done for,' would never amount to anything, others did not want him around, etc. In church he felt that the clergyman was talking at him because he talked of vices, and he asked if he should not get up and confess. He was unoccupied, complained of feeling dull in his head, heavy, and said his mind was weak and that he could not remember things. He said very little. Objectively his memory was not found to be particularly poor, he was oriented in regard to the place and time, and he knew the names of those with whom he came in contact. His calculation ability was poor, and he said it was difficult for him. He improved during the five months of his stay and was discharged in May, 1903. Later he became abnormally irritable and excited and returned to the hospital August 2, 1904. During the interval of over a year he drank frequently and at these times neglected his business. At such times he talked alternately, religiously and profanely. During the six weeks previous to his re-entrance to the hospital he was more talkative, sometimes abusive, and he took no rest and went to meals irregularly. During this period he was arrested twice for acting peculiarly. His manner at the hospital was a jolly one, and his talk showed a "flight." He remained exhilarated as evidenced by his general activity in sports and in his movements and talk. He was apt to become irritable at the slightest provocation. This was his condition during the experiments. In May, 1905, it was noted that he had become a little quieter, but that he made the impression of still being mildly exhilarated. July 29, 1905, the patient was discharged. He had become less exhilarated, but remained active. His conversation was clear and not particularly expansive. Throughout the last attack the patient did not seem to realize that his condition was abnormal. The diagnosis that was made was "Manic-depressive insanity, circular form." For a time, and particularly during the first two at-

tacks, there was considerable doubt about the diagnosis. At first he was considered a case of "General paralysis." This was due largely to the presence of certain physical signs, *e.g.*, no pupillary reaction to light, but good reaction to accommodation. Later the tendo Achillis reflex was noted to be absent, but there were no speech defects, no tremors, no gait disturbances, and the other reflexes were found to be normal. In view of the facts that there is no noticeable dementia, and that there is a regular alternation of the depressions and excitements, it seems most probable that the man is not a case of paresis. If, however, it happens that he is found to be paretic, the results of the experiments would not be affected, because at the time the tests were made he was undoubtedly in an excited, maniacal condition without dementia. The pupillary disturbance, I think is the result of the man's occupation. He has to look alternately at bright lights and to dark objects, and this would tend to reduce, perhaps abolish, the light reflex.

P., was a bright business man, age 48 at the time of his admission to the hospital, May 29, 1904. At this time he was greatly excited and exhilarated, and remained under hospital care until December 5, 1904, when he was discharged on a visit home. A month later he was brought back to the hospital very depressed, after a suicidal attempt. He is now in the hospital (November, 1905). The course of his disease is a typical mania-melancholia, the *manisch-depressive Irresein* of Kraepelin. Three years previous to the present attack P. had bought a business on a friend's advice and when he found later that it was much worse than any one could have expected, he became melancholy. This abnormal depression was, however, only of a short duration, a couple of weeks. Four weeks before entrance to the hospital P. again became 'worked up' over his business, but this time the insanity took on the excited form. Much extra work had been thrown upon him in the business in which he was engaged, and, in addition, he was occupied with the affairs of another concern that he was purchasing. He took a trip to New York in connection with the new business, and there was very erratic. For example, it is said that he bought 500 pocket knives and distributed them among the street gamins. Returning to Massachusetts he wrecked the furnishings in a Pullman coach, was arrested and finally brought here. On entrance he was talkative, excitable, meddled with everything. He seemed to be perfectly clear in regard to his surroundings. He was expansive, euphoric, and quite convinced of his own power and excellency. There was, however, no absurdity in his expansiveness or in his general behavior. He showed insight into his condition, realized that he was excited and irritable, but wanted to go to a summer

resort for rest rather than remain in the hospital. There was a marked flight of ideas. He knew the other patients were insane, knew the names of the people, and was oriented as to place and time. He remained in that condition for about five weeks. Then he became more excited, would not keep his clothes on, was violent when an attempt was made to restrain him. In this state he talked of religious matters and sang very often. He believed that he saw worlds made, and that he lived in another world, although he appeared to be perfectly clear in regard to his surroundings, and only once did he not recognize people. After a week of this violent excitement, he became calmer although still much exhilarated. His talk was voluminous and he did not occupy himself beyond writing letters about his business ventures and erotic epistles, all comparable to his talk. About the middle of September the patient showed signs of improvement. He tended to keep to his room more and not to meddle with things, although he was still exhilarated. He began to have some insight into his condition, explaining it as "brain fever." Later he ceased his continuous talking, although he would chatter so long as any one would ask him an occasional question. He gave up writing letters, and read much with enjoyment. Four or five weeks later he was not so active but remained exhilarated. His talk, however, was more hopeful than his financial affairs warranted. It was in this condition that he first came to the laboratory, and the experiments continued until he was discharged in December. In the meantime, he gradually became more natural in actions and talk, and his excitement was noticed only in a great activity in his games and amusements. As has been said, a month later he returned to the hospital depressed and retarded.

During the time of the experiments, therefore, B. and F. were normal subjects, Ed. and Ev. were greatly depressed and retarded, and C. and P. were mildly excited and expansive. The four last cases, possibly with the exception of Ev., showed a considerable improvement during the course of the experiments both in the laboratory and on the ward. Ev. improved greatly in rapidity in the laboratory, as will be shown later, and he talked more freely and louder, but on the ward there was no appreciable improvement. At no time did any of the subjects show any difficulty in thinking and there was in none of them any appreciable (by tests) memory or attention disorder.

All the subjects seemed willing to take part in the experiments; some of them were anxious to show how well they could do. The experiments also gave them a change of scene and

occupation, which was probably an agreeable change to them from the monotony of their ordinary life. The results, therefore, are as trustworthy, it seems to me, as could be expected with normal people of the same grade of intelligence.

The series was continued in some cases for a period of fifteen weeks with intervals, but some of the patients were not used for more than half that time. The results from all the subjects are comparable if we take the results in serial weeks as will be done. The degree of retardation in Ev. and Ed. differed, but so far as the general problem is concerned, this variation is not of great importance. C. and P. at the time of the experiments did not greatly differ in the degree of exhilaration, but if there was a difference, P. was probably the more excitable.

Description of Experiments. All the work to be reported in the present paper deals with the time of certain mental processes. A number of other experiments were made on accuracy, memory, judgment, and apprehension, but these will not be published at this time. The object of the time tests was to determine the amount of slowing in the cases of retardation, and any marked increase in ability in the exhilarated patients who were convinced of their own excellency.

The following seven kinds of experiments were made:

- A. The time of rapid tapping.
- B. The time of the simple reaction to sound.
- C. The time of choice reactions to sounds.
- D. The rapidity of reading.
- E. The time of discriminating and marking out letters.
- F. The time of adding.
- G. The time of discriminating and distributing colored cards.

In addition to these tests a few other time measurements were made and these fewer and less systematic experiments will be mentioned incidentally in the text. It should be noted that most of the tests were made as simple as was consistent with accuracy, in order that the same kinds of experiments might be performed later on the wards with other patients, who could not conveniently be brought to the laboratory, or who might become unduly excited in a strange situation. With the exception of the reaction time experiments, the tests were of such a character that the patients were tolerably familiar with the materials and methods that were employed.

The results have been grouped by weeks, and the average weekly averages are given in the following tables unless otherwise designated. From these averages the average variations were calculated and these are also given in the tables. The number of experiments in one week varied with the character of the test. In such tests as rapid reading, tapping time, etc.,

usually five determinations were made each week, but in the reaction time experiments from ten to one hundred were made each day. The numbers of experiments of each kind are noted in the appropriate tables. The arbitrary weekly division of the results was made in order to determine the practice effect.

A. The method for determining maximum rapidity of tapping was as follows: A sheet of paper, 8 x 10 inches, was placed before the subject, a pencil was given to him, and he was instructed (and shown) to tap progressively in lines back and forth on the paper at his maximum speed. The signals for starting and stopping were explained to him, and the experimenter watched the tapping of the subject to see that the beginning and end of the process coincided with the signals. The tapping movement was made by the forearm, although no insistence was made on this point. Most of the subjects remained seated at the table for the experiment, but one (C.) said it was much easier for him to stand up to tap. Thirty seconds was chosen as a convenient time in which the subject had an opportunity of warming up and of attaining his maximum speed, and it seemed not sufficiently long to show any plain evidences of fatigue. In this method there is a possibility of a constant error of plus one tap, but probably not more, and this constant error was probably the same in all the subjects. The number of taps in the thirty seconds was counted, and the time for making one tap was found by dividing the total time by the number of dots on the paper. The differentiation of the parts of the tapping process, *i. e.*, the holding down, the holding up, etc., could not be calculated from the records. Such details were considered unnecessary in this work. Usually only one experiment of this character was made each day.

B. The time of simple reaction to sound was determined by means of a Hipp chronoscope. The patient was instructed to hold down the electric key, and to release it so soon as the sound was heard. The stimulus was produced by an electric telegraph sounder, and was a clear, sharp, rather loud sound. Two or three days' practice in reacting to the sound was given to each subject before any time measurements were made. This was done to familiarize the subject with the apparatus and to get rid of any possible fear of electricity, etc., that might have been present at the beginning. None of the patients showed, however, the least sign of fright, and all reported that they had none. In each day's series about half a dozen practice reactions were made before the time measurements were taken. All the subjects were right-handed, and only the right hand was used in these experiments. The chronoscope was controlled frequently by a fall hammer. In

the calculation of the records the weekly averages and the average variations were determined.

Experiments on the reaction to light and tactile stimuli are planned to supplement the present ones on sound, and reactions with the lips as well as with the hand. For a solution of the general problem, *i. e.*, the localization in the nervous system of the retardation and excitation processes such experiments will probably be necessary.

C. The sound apparatus used in the experiments on simple reactions was employed in the choice reaction tests to give a loud sound (same intensity as in simple reactions), and for the less intense sound a telegraph key was hit gently. The intensity and quality of the low sound differed from the other sound, and the intensity probably also varied in the different experiments. The right hand reacted to the sound for the telegraph sounder, as in the simple reactions, and the left reacted to the sound from the telegraph key. The reactions with the right hand were used for comparison with the times of the simple reactions. Only these right hand reactions were timed, but the subjects did not know that the left hand reactions were not being taken. This procedure, *i. e.*, considering only the right hand reactions, was necessary in order to make the results comparable with the results for the simple reactions.

D. The time necessary to read aloud one word was found from a rapid reading of a page of printed matter from three hundred sixty to four hundred words in length. The subjects were given the page of printing and instructed to read aloud at a maximum speed to the end of the page. The total time divided by the number of words gave the average time for reading one word. The matter which was read was unfamiliar to all the subjects. The words, however, were neither peculiar nor difficult. The type was 10-point, single leaded. In experiments such as these the time will vary greatly with the individual, since education and previous practice play great parts in the ease of reading. The patients who were used, however, did not vary very much in their average of intelligence, and possibly not much in their reading practice. It is possible that C. was least intelligent and the least read of all the patients and Ev. the most intelligent and most widely read. These are the impressions the writer got from careful observation of the subjects, but it is extremely difficult, almost impossible, as all know, to make any accurate estimate.

E. One hundred E's in a number of words with an average total of 850 letters were to be discriminated and crossed out as rapidly as possible. The subjects were not informed how many letters there were to be crossed out, but only to do the work accurately and rapidly. This experiment, but with 100 A's in

a total of 500 letters, was used in the tests of the Columbia College students.¹ The time for the total task was taken by a stop watch. The number of omissions was noted. The proposed method of calculating the results by lengthening the time proportionately to the number of omitted letters was tried, but was given up. The total time in any one experiment is the sum of the time for discriminating the 850 letters, and the time for marking the 100 E's. In the tables both the total time and the number of omissions are given. This test was very unsatisfactory, owing to the two factors of variability, time, and accuracy. With some subjects the accuracy did not greatly vary, and with others the time was fairly constant.

F. The time of adding was obtained from a series of twenty problems. Each problem consisted of two five-digit figures,

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one placed over the other, *e. g.*, 34924. I had prepared twenty-eight different sheets, each with twenty problems, and each problem differing from the others. These sheets were used in regular order for each of the subjects. The time interval between the first and second use of any particular sheet was so long that there could be no memory of the particular problem. The results of the additions were written by the subjects below the problems, and a check could then be made on the accuracy. The total time, from the start until the last figure in the sum of the twentieth problem was written, was noted. In some cases, particularly Ev. and, at first, Ed., there was considerable hesitation between the problems, and these two subjects had at first to be 'prodded' to proceed to the next problem. There was, accordingly, considerable lost time, and this also was noted. If this lost time is subtracted from the total time we can find the actual time for the addition and the writing of the answers. In the tables in which these results are found there will be noted the designations, 'total time' and 'actual time.' These results are to be understood as explained above. No determinations of the 'actual time' could be made on the writer.

The time lost between the problems could be determined only approximately; the error may be as much as one half second, but probably there were sufficient plus and minus variations in the individual estimations of the nineteen intervals to counterbalance to some extent.

F. The discrimination and marking of the E's proved in so many ways a difficult test to interpret that a few weeks after

¹ See Cattell and Farrand: Physical and Mental measurements of the Students of Columbia University, *Psychol. Review* (1896), III; and Wissler: The Correlation of Mental and Physical Tests, *Psychol. Review Monograph Suppl.*, No. 16, 1901, pp. 62.

the beginning of the series on Ed., Ev., and F. I introduced the additional experiment of discrimination and distribution of colored cards. Ten cards each of a different color were placed in a semicircle on the table in front of the subject, and he was given a pack of one hundred colored cards, ten cards of each of the colors represented on the table. He was instructed to distribute the cards as rapidly as possible, and to place the cards of one color in the appropriate place. The cards were so shuffled that no two cards of the same color came together in the pack. Each card was three inches square. The colors I used were: white, light pink, pink, red, yellow, gray green, very light green, light blue, blue, gray. The cards were placed in the foregoing order beginning either at the left or right hand. Sometimes the white, pink, red end of the semicircle was placed at the right, sometimes at the left. No regular order was used and no habit in that respect could be formed. There was sufficient difference in the colors to make them easily distinguished from each other, but the differences between white and light pink, light green and light blue, and gray and green gray, were on the other hand sufficiently small to demand close attention to the distribution. Occasionally a subject would put two cards at one time in the pile, the second card not having been handled and discriminated. This was always counted as one error. More often the mistakes were mistakes in discrimination. The cards which were the most difficult to discriminate were sometimes confused, for example, a gray would be placed on the green gray pile. Sometimes in these piles there would be collections as follows, pink, pink, pink, white, white, white, etc., and white, white, white, pink, pink, etc. Each of these arrangements was counted one mistake, since the discrimination and sorting went on just as if the white and pink positions had been interchanged. The time given in the tables is the time obtained plus a proportionate amount for the errors of omission.

In the tables the averages are grouped according to the serial weeks, to make the results of all the subjects as comparable as possible. The experiments were not, however, made at the same time. The series on Ed., Ev. and F. were begun August 22-27, B's series, Sept. 5-10, and the series on C. and P. Oct. 23-29, 1904. A few experiments were made on Ev. August 21, 22, 23 and 24, 1905. S., a subject in another series of experiments, but whose results will be considered in the appropriate places, was used July 6-21, August 8-19, and August 21-26, 1905. All the experiments on C., P. and S. were begun on the same day. The experiments on sorting the colored cards, it has been mentioned, were not begun for some

time after the other tests with B., Ed., Ev., and F., and the reaction time experiments were not begun until the third week of the tapping, reading, etc., on Ed., Ev., and F.

Experimental Results. Tapping time. The results of the tapping experiments are given in Table I. Here we find that on the whole the two excited subjects show no variation from the normal, but that the retarded patients are much slower than either the normal or excited subjects.¹ B. and F. start

TABLE I.

Weekly averages of tapping time in thousandths of a second. The average variations are given below the averages. The numbers of experiments, when more or less than five, are in parentheses.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|------------------|---------------------|---------------------|---------------------|----------------------|---------------------|---------------------|
| | B. | F. | Ed. | Ev. | C. | P. |
| I | 156.7 2.6 (4) | 153.7 5.7 (6) | 221.8 9.8 (3) | 299.3 45.2 (3) | 180.5 9.8 (4) | 149.0 5.5 (4) |
| 2 | 153.2 3.4 (3) | 139.7 1.8 (3) | 195.6 23.4 | 264.2 16.2 | — | — |
| 3 | 160.8 1.9 | 132.4 8.6 | 172.2 6.2 (6) | 230.7 9.6 (6) | — | — |
| 4 | — — | 127.2 2.1 | 169.4 3.5 | 235.0 3.2 | 184.6 6.7 | 145.4 2.6 |
| 5 | — — | 128.6 4.7 | 165.4 3.9 | 231.0 13.6 | — | — |
| 6 | 161.8 3.4 (4) | — — | — — | — — | 185.0 2.4 | 140.2 1.0 |
| 8 | — — | 120.4 2.5 | 164.0 5.6 | 232.0 4.8 | — — | — — |
| 9 | 157.0 4.0 | — — | — — | — — | — — | — — |
| II | — — | 121.2 1.8 | 161.6 4.7 | 224.4 3.9 | — — | — — |
| 15 | — — | 127.0 3.6 | — — | 234.4 5.9 | — — | — — |
| General average. | 157.8 (23) | 131.4 (39) | 178.4 (36) | 240.7 (39) | 183.6 (14) | 144.6 (14) |

¹ Dresslar (Some influences which affect the rapidity of voluntary movements, *Amer. Jour. Psychol.*, 1892, IV, 514-527) found that it took 37 seconds, to make 300 taps on the first day of his series, *i. e.*, 0.123 sec. for one tap. He does not state whether or not this experiment had been preceded by any practice tests. His general conclusion

with approximately the same speed, but, while F. improved and greatly lessened his time, B. did not gain in speed with practice. Neither C. nor P. show much practice effect. The slight improvement shown by P. is due mainly to one chance result on the third day of the first week, when his time was greatly slowed, to .157 second. On this day it was noted that P. was greatly distractible, and that he kept talking throughout the experiment. If this result be excluded there would be no difference between the results of the first and the fourth weeks. This distractibility was noted throughout the series on both C. and P., particularly at the beginning. The practice effect shown by Ed. is coincident with his general mental improvement, and it is difficult to estimate how much of the increased speed is due to the recovery of the patient and how much to the practice. In this and in the other experiments, as will be shown later, Ev. attained his greatest speed after two weeks' practice, and thereafter the extra practice did not seem to decrease the time for the performance of any of the tests. This is very different to the result found with Ed., and to that obtained from another depressed and retarded subject, S. The results of similar experiments on S. over a period of thirteen weeks are given in Table II.¹ S. shows the gradual increased speed from practice, but in this case, it is also impossible to estimate the amounts due to recovery and to practice. The fact that there is an increased speed from the ninth to the thirteenth weeks, when there were no experiments in the interval, would indicate that a large part of the 'practice effect' was due to the recovery. Similar reductions in time are noted in the figures given by Ed. for the fifth and eighth weeks, and for the eighth and eleventh weeks.

TABLE II.

*Weekly averages of tapping time in thousandths of a second.
Subject, S., retarded depression.*

| Serial weeks. | 1 | 2 | 3 | 6 | 7 | 8 | 9 | 13 |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Averages, | 243.3 | 220.0 | 204.7 | 200.7 | 191.5 | 190.5 | 193.0 | 178.0 |
| Average variations, | 14.3 | 13.5 | 6.9 | 7.6 | 6.2 | 7.6 | 1.0 | 7.0 |
| Numbers of experiments. | 4 | 12 | 10 | 10 | 12 | 12 | 2 | 2 |

from his work is that the "normal rate for most rapid voluntary movement of the right wrist was found to average 8.5 taps per second." Other tapping results, but with restricted movements, will be found in an article by Bryan: On the development of voluntary motor ability, *Amer. Jour. Psychol.* (1892), V, 125-204.

¹ S. had been used in another part of this general research, and his

In five experiments Ca., another retarded subject, averaged 162.8 taps in 30 seconds, average time for one tap 0.184 sec. In these five experiments there was noticeable some practice, but owing to mental confusion it was deemed advisable not to continue the work. Pr., a depressed case without retardation but with a feeling of inadequacy,¹ showed considerable speed in movement. Two experiments averaged 196.5 taps in thirty seconds, average time for one tap 0.153 sec. Arranging the subjects in the order of rapidity we have: F., P., Pr., B., Ed., C., Ca., S., and Ev., if all the experiments are grouped, but if the first week's results are considered alone we find the following order: P., Pr., F., B., C., Ca., Ed., S., and Ev. The last four subjects, it will be remembered, were retarded at the time the experiments were made.

The average variations are relatively small, with two exceptions, viz., Ev's first week, and Ed's second week. In both cases the size of the deviation is due to one relatively slow day.

Reaction time. The results of the simple and choice reactions to sounds will be found in Tables III, IV, and V. The experiments on B., C., and P. were begun at the same time as the other tests. Those on Ed. and Ev. were not begun until the third week. Ev. is the only subject to show any great variation from the normal in either simple or choice reactions.

TABLE III.

Weekly averages of simple reactions to sound, in thousandths of a second. The average variations are given below the averages. The numbers of experiments are in parentheses.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|---------|-------|------------|-------|----------|-------|
| | B. | F. | Ed. | Ev. | C. | P. |
| 1 | 164.6 | 157.1 | 191.3 | 299.0 | 182.9 | 185.0 |
| | 15.0 | 17.9 | 35.2 | 79.7 | 22.7 | 23.5 |
| | (80) | (140) | (120) | (120) | (240) | (240) |
| 2 | 167.2 | — | 181.3 | 209.2 | — | — |
| | 18.7 | — | 20.8 | 53.3 | — | — |
| | (100) | — | (100) | (100) | — | — |
| 3 | 165.0 | — | 178.2 | 208.3 | — | — |
| | 12.2 | — | 18.7 | 41.5 | — | — |
| | (100) | — | (100) | (100) | — | — |

results will be mentioned in this paper in connection with the appropriate experiments. S., a business man, was 44 years old at the time the experiments were made. He had had two previous attacks of depression with retardation. The attack in which he was the subject of some experiments began in March, 1905, and he was discharged from the hospital in September. A full account of the work on S. will appear in a forthcoming number of the *American Journal of Insanity*.

¹ *I. e.*, a feeling that things are more difficult to do, and a disinclination to do things.

TABLE III. *Concluded.*

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|------------------|------------------------|-------------|------------------------|------------------------|------------------------|------------------------|
| | B. | F. | Ed. | Ev. | C. | F. |
| 4 | 158.4 14.0 (540) | — — — | 186.1 34.3 (530) | 224.0 48.0 (610) | 173.7 16.7 (300) | 187.5 15.8 (300) |
| 6 | 159.9 14.3 (80) | — — — | — — — | 282.9 62.6 (100) | 167.9 14.0 (240) | 195.2 19.2 (270) |
| 9 | 163.6 11.0 (300) | — — — | — — — | 175.7 19.1 (300) | 311.5 57.1 (300) | — — — |
| 13 | — — — | — — — | — — — | 342.8 73.6 (380) | — — — | — — — |

If the average simple reaction time obtained in the tests of college students¹ be taken as the normal average for unpracticed subjects we find the results of B. and F., the two normal subjects used in this work, differ very little from the normal average. The averages of C., Ed., and P. for the first week do not greatly exceed Wissler's determinations plus the probable error (*i. e.*, 158.7+18.9). Ed. always reported that in this experiment his attention was directed to making the movement. If this statement be accepted as evidence of motor reactions, his reactions may be considered slow. It should be noted, however, that when well enough to be discharged his average (ninth week) was 175.7. Another retarded subject, S.,² averaged for 350 experiments, 50 on each of seven days, 215.4 (probably sensory reactions). The first set of twenty-five reactions averaged 325.6 and the last set 152.2. This is a decided slowing in the first experiments, and there is a wonderful practice effect in the increased speed of the reaction. The results of the tests of the Columbia students are, however, not directly comparable to the averages for the first week of my subjects. It would be more justifiable to compare the results obtained on the first day from the subjects I used. In this case it should be remembered, as has been noted above, that the subjects were practiced for a time before any time measurements were taken. The results of the first day's simple reaction averages are as follows: B., 164.1; Ed., 144.1; Ev., 446.2; C., 185.9; P., 192.9. The perfectly normal character of Ed's

¹ Wissler: The Correlation of Mental and Physical Tests. *Psychological Review Monograph Supplement*, 1901, III, No. 16, pp. 62. Wundt gives 120σ to 180σ as averages of normal subjects, *Physiol. Psychol.*, III, p. 416.

² See above for a very brief account of his condition.

reaction on the first day is remarkable. On the remaining five days of this week, however, this subject averaged respectively 213.0, 189.8, 213.8, 212.0, and 195.7. The reactions on these days are slowed, and are not consistent with the results of the first day. The averages for the excited patients, C. and P., show no shortening of the reaction time, but on the contrary if the difference to the normal is considered sufficient to notice it is a decided slowing. The results which I have obtained should be compared with the results of other investigations. The averages given by Richet¹ for simple reactions to sound are 194 for cases of melancholia and 156 for mania. Bevan Lewis's experiments show a simple reaction to sound in melancholia to be very long, 0.23 second.² The average for five maniacal patients was 186. Some of Lewis's patients, that were greatly depressed, gave very rapid reactions, *e. g.*, J. H. B., .13 sec.; C. K., .14 sec.; and J. E., .13 sec. None of his excited patients gave average simple reactions less than .17 sec. In Marie Walitzky's experiments on the reaction time to sound, it was found that in two cases of excitement the simple reaction was .172.³ v. Tschisch gives the average of 150 simple reactions to sound by a patient recovering from mania 0.07 second,⁴ but I feel confident that this time is too short to be considered typical of these cases. No other observer has, to my knowledge, found such a shortening of the time. Janet has also made numerous determinations of the reaction time in depressed conditions.⁵ He seems to find in these conditions a slowing of the reactions. The results obtained by Buccola⁶ I.

¹ *Dictionnaire de Physiologie*, Vol. III, p. 29. Article *Cerveau*. No definite information is given regarding the cases used in obtaining these results, and it is impossible to draw any comparison with the retarded patients with whom I worked. Richet says that his results are averages of many observers.

² W. Bevan Lewis: *Text-book of Mental Diseases*. London, 1899, pp. 164, 364, and 365. The designations of the subjects do not indicate whether or not retardation was present.

³ Walitzky: Contribution a l'étude des mensurations psychométriques chez les aliénés, *Revue Philos.*, 1889, XXVIII, 583-595. These cases, it should be mentioned, are maniacal conditions in general paralysis.

⁴ W. v. Tschisch: Ueber die Zeitdauer der einfachen psychischen Vorgänge bei Geisteskrankheiten, *Neurol. Centralblatt*, 1885, IV, 217.

⁵ See particularly *Névroses et idées fixes*, 2 vols., Paris, 1898. Janet's results are given in the form of curves. The printing or the engraving of the cuts is so badly done that it was impossible, even with the aid of a microscope, to determine the figures which he has obtained. The general character of the curves give a fair idea of his results, however. In the case of depression, Bei, it appears that the simple reaction to sound averaged from 200 to 220 (Vol. II, p. 67).

⁶ Buccola: La legge del tempo nei fenomeni del pensiero. *Biblioteca scientifica internat.*, Vol. XXXVII. The work done on the insane by this investigator is said to be very good, but I have been unable to get the articles. His work is referred to by Walitzky.

regret to say I have not seen. The *debile* whose reaction times are given by Pelletier is probably a case of dementia.¹

The choice reaction times obtained by other experimenters for normal, depressed and excited students are very varied. In choice experiments similar to those made by me Tischer found on nine subjects an average of 316,² with an individual variation from 293 to 357. In Kraepelin's laboratory numerous experiments on the choice reaction times gave averages from 250 to 350. Walitzky found the choice reactions of two excited cases to average 653, although the simple reaction was only 172.³ v. Tschisch⁴ found a corresponding and almost proportionate increase in his case of 'recovering mania.' Lefmann,⁵

TABLE IV.

Weekly averages of choice reaction times in thousandths of a second. The average variations are given below the averages. The numbers of experiments are in parentheses.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|---------------|--------------|---------------|---------------|---------------|---------------|
| | B. | F. | Ed. | Ev. | C. | P. |
| 1 | 250.1 | 192.4 | 268.0 | 432.0 | 298.4 | 258.9 |
| | 36.3 (40) | 28.1 (60) | 53.3 (60) | 82.3 (60) | 60.7 (120) | 41.5 (120) |
| 2 | 239.4 | — | 251.2 | 306.8 | — | — |
| | 22.9 (50) | — | 39.8 (50) | 71.8 (50) | — | — |
| 3 | 234.8 | — | 223.9 | 338.1 | — | — |
| | 16.2 (50) | — | 20.6 (50) | 75.2 (50) | — | — |
| 4 | 236.9 | — | 257.2 | 304.5 | 276.9 | 262.1 |
| | 29.3 (280) | — | 44.1 (320) | 55.8 (330) | 47.1 (150) | 32.3 (150) |
| 6 | 230.3 | — | — | 308.5 | 257.4 | 234.0 |
| | 25.6 (40) | — | — | 47.1 (50) | 58.0 (120) | 38.7 (120) |
| 9 | 236.8 | — | 241.9 | 313.4 | — | — |
| | 27.9 (180) | — | 35.6 (150) | 48.5 (240) | 24.7 (210) | — |
| 13 | — | — | — | 357.6 | — | — |
| | | | | 24.7 (210) | — | — |

¹ Pelletier: *Les lois morbides de l'association des idées.* Paris, 1904. See p. 133.

² Wundt: *Physiol. Psychol.*, III, 461.

³ *Op. cit.*

⁴ *Op. cit.*

⁵ Lefmann: Ueber psychomotorische Störungen in Depressionszuständen, *Psychol. Arbeiten*, 1904, IV, 603-668.

TABLE V.

Differences between weekly averages of choice and simple reaction times in thousandths of a second.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|---------|------|------------|-------|----------|------|
| | B. | F. | Ed. | Ev. | C. | P. |
| 1 | 85.5 | 35.3 | 76.7 | 133.0 | 105.5 | 73.9 |
| 2 | 72.2 | — | 69.9 | 97.6 | — | — |
| 3 | 69.8 | — | 45.7 | 129.8 | — | — |
| 4 | 78.5 | — | 71.1 | 80.5 | 103.2 | 74.6 |
| 6 | 70.4 | — | — | 25.6 | 89.5 | 38.8 |
| 9 | 73.2 | — | 66.2 | 1.9 | — | — |
| 13 | — | — | — | 14.8 | — | — |

working in Kraepelin's laboratory, obtained the following averages respectively for six typical cases of depression-retardation (200 choice reactions each, no simple reactions are reported): 325, 371, 406, 469, 474, 685. The average variations for Lefmann's subjects were very large.¹

F's choice reactions are very short. This is, I think, due to the fact that he knew the conditions of the experiment—that the reactions of the left hand were not being considered. Although an attempt was made to react naturally with both hands, the knowledge of the methods tended to make him pay more attention to the right hand and the loud sound. This was noticeable in that several times he failed to react with the left hand at the proper time. The times given by B., C., Ed., and P. are shorter than those of the majority of Tischer's eleven normal subjects. Ev., however, took a much longer time to differentiate the two sounds and to react properly. The two excited subjects, C. and P., do not show any increased rapidity, and in fact their lowest weekly averages are not so low as the lowest weekly averages of Ed's experiments.

The results of experiments with S. were about the same as with Ed. The general average for seven days was 256.9. On

¹ The results of Lefmann's work are mentioned here mainly for the sake of completeness. It seems to me that his methods of experimentation or of calculation must have had considerable errors which do not appear from the description. Only in this way can I understand the results from a maniacal patient, Ba., who in 50 choice reactions had an average of 153 and an average variation of 160. In other respects the article is not good. The author keeps referring to other work for methods, especially to work of Kraepelin or his pupils, and does not give any other indication in his article of what is there attempted. For example, in the article L. does not state what kinds of stimuli were used in the reaction experiments. For this we must refer to a monograph by Kraepelin published twelve years before.

the first day of his series he averaged 450.9, and on the last day 218.8. It should be remarked, however, that at the time the last experiments were made S. was practically well.

The differences between the simple and choice reaction times are about normal in five of the subjects. In the case of Ev., on certain days the simple reaction time equalled and sometimes exceeded the choice reaction time.¹ It is a striking fact that the choice time in the two excited subjects, who were supposed to have rapid associational processes, is not shorter than the normal choice time or the choice time of Ed.

Considering the reaction times as a whole it is apparent that the excitability of the maniacal patients is not evidenced by an increase in the speed, and that the retardation is not necessarily a decrease in the speed with which a movement is initiated.²

The average time of reading one word has been determined by Cattell for himself to be 0.138 second, and Richet³ has found that he is able to speak, or to think about ten syllables in one second. The results on the six subjects of the present work are given in Table VI. The time taken by my two normal subjects, B. and F., is much longer than that taken by Cattell. P., an excited subject, took about the same time as B.; C., Ed., and Ev. are distinctly slow.⁴ As the experiments progressed the normal and depressed subjects improved, but the excited patients did not. The percentages of improvement due to the exercise in this test, *i. e.*, one hundred minus the best weekly average divided by the average for the first week, are as follows: B., 10%; F., 13%; Ed., 37%; and Ev., 18%.

¹ These results have been considered in some detail in a previous paper. Franz: Anomalous Reaction Times in a case of Manic-depressive Depression. *Psychol. Bulletin*, 1905, II, 225-232. Similar results were obtained in later experiments with S. The condition, therefore, is one which may be more or less characteristic of certain cases of retardation. A full account of the work on S. will be found in the *American Journal of Insanity*, Franz and Hamilton: The effects of exercise upon the retardation in conditions of depression, 1905.

² From the results of fatigue experiments Hoch has concluded that the retardation comes principally at the beginning of a movement; On certain studies with the Ergograph, *Journal of Nervous and Mental Diseases*, 1901, XXVIII, 620-628. The present series of experiments do not bear out this conclusion, but I prefer to await further results before making any definite denial on this point. I believe the explanation offered by Hoch for the conditions which he found to be the most plausible one, although it does not fit the results of the present work.

³ *Dictionnaire*, III, p. 10.

⁴ The calculation of a few records on the basis of syllables gave for F. .104 sec. for reading one syllable. The time of the other subjects for reading a syllable may be determined approximately by multiplying the figures in the table by .6.

TABLE VI.

Weekly average time in thousandths of a second for reading one word.
The average variations are given below the averages. The numbers of experiments, when more or less than five, are in parentheses.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|----------------------|----------------------|----------------------|---------------------|----------------------|----------------------|
| | B. | F. | Ed. | Ev. | C. | P |
| 1 | 276.3 19.9 (4) | 198.0 5.0 (2) | 545.0 86.5 (4) | 394.0 9.0 (2) | 329.0 16.0 (4) | 266.0 10.0 (4) |
| 2 | 277.6 14.2 (4) | 179.8 11.8 (4) | 497.2 22.6 | 323.0 24.4 | — | — |
| 3 | 253.4 22.3 (4) | 183.5 12.5 (4) | 470.0 14.0 (6) | 337.8 5.7 (6) | — | — |
| 4 | — | 186.6 2.5 | 451.2 13.8 | 346.2 12.2 | 342.6 13.9 | 269.2 18.2 |
| 5 | — | 176.8 7.3 | 378.8 29.8 | 321.6 20.5 | — | — |
| 6 | 249.8 9.5 (4) | — | — | — | 368.8 28.0 | 276.8 6.6 |
| 8 | — | 172.0 6.8 | 347.8 12.6 | 322.6 24.3 | — | — |
| 9 | 248.6 16.3 | — | — | — | — | — |
| 11 | — | 181.2 9.8 | 342.0 14.0 | 329.0 18.0 | — | — |
| 15 | — | 194.4 4.9 | — | 373.0 10.4 | — | — |

TABLE VII.

Weekly averages of time in seconds for marking 100 e's. The average variations are given below the averages, and on the third line the average number of mistakes. The numbers of experiments, when more or less than five, are given in parentheses.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|-----------------------------|---------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|
| | B. | F. | Ed. | Ev. | C. | P. |
| 1 | 110.2 13.8 3.2 (6) | 96.0 6.7 2.3 (5) | 145.2 13.6 7.3 (6) | 131.5 32.8 33.2 (6) | 135.8 7.4 13.5 (4) | 149.2 18.8 14.5 (4) |
| 2 | 108.8 7.0 1.8 | 82.6 5.1 0.6 | 123.6 14.7 5.4 | 153.6 17.1 18.4 | — | — |

TABLE VII. *Concluded.*

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|------------------|---------|------|------------|-------|----------|-------|
| | B. | F. | Ed. | Ev. | C. | P. |
| 3 | 111.0 | 83.4 | 104.6 | 152.0 | — | — |
| | 6.0 | 9.3 | 6.7 | 13.6 | — | — |
| | 2.4 | 0.2 | 5.8 | 16.0 | — | — |
| 4 | — | — | — | — | 132.8 | 143.4 |
| | — | — | — | — | 4.6 | 12.1 |
| | — | — | — | — | 11.4 | 2.4 |
| 6 | 112.0 | 80.0 | 108.0 | 154.4 | 130.6 | 131.0 |
| | 7.2 | 8.5 | 5.2 | 10.3 | 5.5 | 3.6 |
| | 1.8 | 0.3 | 6.0 | 18.6 | 7.4 | 2.0 |
| 9 | 103.6 | 79.6 | 102.6 | 163.4 | — | — |
| | 8.1 | 5.9 | 6.3 | 16.5 | — | — |
| | 0.2 | 0.0 | 3.4 | 12.0 | — | — |
| 13 | — | 76.0 | — | 166.8 | — | — |
| | — | 7.5 | — | 8.2 | — | — |
| | — | 0.0 | — | 14.2 | — | — |
| | | (4) | | | | |

The discriminating and marking of the one hundred letters in the paragraph of printed matter was at first a very slow process in both the depressed and excited patients. Table VII gives the results of the six subjects. The averages and average variations as well as the average number of errors are given. These experiments were begun at the same time as the reaction experiments, *i. e.*, 3d week for F., Ed., and Ev. As the experiments progressed there was an increase in speed and a decrease in the number of omitted letters for all the subjects except Ev. Practice increased Ev's time but also increased his accuracy. These results cannot be directly compared with the results obtained from college students,¹ but in comparison both B. and F. are quite rapid in the performance of the task. Neither C. nor P. are so speedy as the two normal subjects, and P. is slower than the retarded patient, Ev. There is not much difference in time for the first weeks of C. and Ed., C. was a trifle faster, but Ed. was considerably more accurate. Ed. was quicker than B. after the second week, but he did not approach in accuracy to that of B. Ca., another retarded subject, averaged in four experiments 123.5 sec.; A. V., 10.3.; with average omissions 36.5. These results are similar to those of Ev. The time taken by S. for this experiment averaged longer than Ed's time; twelve experiments in one week, average,

¹ Wissler: *op. cit.*, 270 college students discriminated and marked one hundred A's in a total of six hundred letters in 100.2 seconds with an average of 2.2 errors.

152.7 sec.; A. V., 8.6; average number of omissions, 10.1. In this case practice for one week decreased the number of errors, but not the time.

The results of the adding experiments are given in Tables VIII and IX. The actual time was not determined for F. and no results are given for him in Table IX. P. is the most rapid of all the subjects, probably because a large part of his business was that of bookkeeping. Ed., who had had considerable experience in adding in his business as hotel clerk, was noticeably retarded, particularly during the first two weeks. The total and actual times taken by Ed. were greater at first than any other subject, and C., who had had little experience in this kind of work, may be considered approximately normal, although the time which he took for the work was more than that of the other excited patient or of the two normal subjects.

The actual time gives a more accurate estimate of the rapidity or slowness in the additions than does the total time. The two cases of retardation had to be prodded continually at first to keep on with the work, and C. had a tendency to lie back and to rest between each problem, which tendency had to be overcome. This is noticeable in the time lost, the differences between the total and actual times. B. averaged in lost time about 13 seconds, P. 11 seconds, C. 18 seconds, and Ed. and Ev. about 19 seconds in each test. We find, therefore, the following order of rapidity in the first week: P., F., B., C., Ev., Ed. A striking fact is that Ev., who was so decidedly retarded, much more so than Ed., was much more rapid.

TABLE VIII.

Weekly averages of total time in seconds for adding twenty problems. The average variations are given below the averages. The numbers of experiments, when more or less than five, are given in parentheses.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|---------------------|----------------------|----------------------|----------------------|---------------------|--------------------|
| | B. | F. | Ed. | Ev. | C. | P. |
| 1 | 127.5 6.8 (4) | 106.5 11.5 (4) | 312.2 87.4 (2) | 214.0 28.0 (2) | 183.5 4.0 (4) | 90.8 3.5 (4) |
| 2 | 103.7 1.5 | — | 212.6 25.9 | 198.4 29.9 | — | — |
| 3 | 111.6 4.7 | 93.8 5.6 (3) | 177.2 11.8 (6) | 162.5 6.5 (6) | — | — |
| 4 | — | 92.2 3.5 | 157.6 8.7 | 157.8 9.6 | 171.4 3.7 | 85.8 1.8 |
| 5 | — | 88.0 1.6 | 140.4 10.3 | 159.8 5.8 | — | — |

TABLE VIII. *Concluded.*

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|---------------------|--------------------|---------------|---------------|--------------|-------------|
| | B. | F. | Ed. | Ev. | C. | P. |
| 6 | 109.5 1.5 (4) | — | — | — | 164.2 4.7 | 83.2 1.8 |
| 8 | — | 89.8 4.8 (4) | 141.4 13.1 | 162.2 10.6 | — | — |
| 9 | 102.4 0.7 | — | — | — | — | — |
| 11 | — | 85.2 3.0 | 126.4 6.9 | 153.8 6.6 | — | — |
| 15 | — | 82.4 4.5 | — | 161.8 10.6 | — | — |

TABLE IX.

Weekly averages of actual time in seconds for adding twenty problems. The average variations are given below the averages. The numbers of experiments, when more or less than five, are given in parentheses.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|---------------------|--|----------------------|----------------------|---------------------|--------------------|
| | B. | | Ed. | Ev. | C. | P. |
| 1 | 112.6 5.9 (4) | | 279.6 84.3 | 191.5 24.5 (2) | 161.6 7.4 (4) | 78.3 4.5 (4) |
| 2 | 93.3 2.5 | | 177.8 21.0 | 172.6 27.9 | — | — |
| 3 | 100.0 5.4 | | 152.3 10.3 (6) | 142.1 5.4 (6) | — | — |
| 4 | — | | 141.0 6.8 | 143.2 8.8 | 154.6 3.5 | 75.9 1.9 |
| 5 | — | | 127.5 9.0 | 146.2 5.2 | — | — |
| 6 | 95.4 3.9 (4) | | — | — | 148.8 5.8 | 72.9 3.1 |
| 8 | — | | 124.5 9.4 | 142.8 10.4 | — | — |
| 9 | 88.5 0.4 | | — | — | — | — |
| 11 | — | | 111.4 5.7 | 137.0 5.0 | — | — |
| 15 | — | | — | 142.6 11.5 | — | — |

The practice improvement is most marked in the case of Ed., a result which has been found also in the previous experiments. But an increase in speed does not follow an increase in the number of experiments. Very soon, in the third week, Ev. attains his maximum speed and thereafter there is no improvement. All the other subjects improve to the end of their series, and this improvement is marked even when rest intervals of two or three weeks are taken. The greatest improvement is found for Ed. He has much more to be improved. Here again it is difficult to determine how much the increased speed is due to the practice and how much to his recovery. Much of the 'practice effect' is undoubtedly due to the improvement in the mental condition. The greatest improvement in the other subjects is only 25 per cent., *i. e.*, Ev., and in B. and F., with about the same number of experiments the results of the last week show only 22 per cent. gain in speed. In Ed's experiments the times of the last week are only forty per cent. as long as those of the first week, an improvement of sixty per cent.

In the fourth week of the series on C. and P., the ninth week on B., and the eleventh week of the work on Ed., Ev., and F., I had all the subjects count from one to one hundred, and to add as rapidly as possible one hundred two-digit prob-

lems. One hundred problems, *e. g.*, $\underline{2} \ \underline{6} \ \underline{4}$, $\underline{9} \ \underline{3} \ \underline{8}$, were placed on a sheet of cardboard and instructions given to add the individual problems and to speak the results as rapidly as possible. After this I had each subject count at a maximum speed from one to one hundred. The times were taken by a stop watch. The results of the experiments are given in Table X.

TABLE X.

Average time in seconds for adding one hundred two-figure problems, and for counting from one to one hundred. The average variations are given below the averages. The numbers of experiments are in parentheses.

| | Normal. | | Retarded. | | Excited. | |
|-------------|---------|------|-----------|------|----------|------|
| | B. | F. | Ed. | Ev. | C. | P. |
| Problems, | 85.0 | 69.1 | 78.8 | 92.3 | 144.0 | 70.5 |
| 100 | 25.0 | 3.6 | 6.3 | 8.5 | 0.0 | 3.5 |
| | (5) | (7) | (4) | (4) | (2) | (2) |
| Counting, | 37.8 | 22.4 | 31.5 | 62.0 | 51.0 | 34.0 |
| | 0.8 | 1.7 | 2.3 | 4.0 | 0.5 | 0.0 |
| | (4) | (5) | (4) | (4) | (2) | (2) |
| Difference, | 37.2 | 46.7 | 47.3 | 30.3 | 93.0 | 36.5 |

At the time these experiments were made Ed. was not appreciably retarded, *i. e.*, he was not retarded to a degree that

could be determined by observation or by any rough tests. His rapidity in this experiment showed, moreover, that he was not retarded in comparison with the other subjects. C. and P. at this time were both excited.

It is interesting to note that the general time relations between the subjects of the same class are the same for these simple additions and for the more complicated addition problems on the same days. Thus, for example, Ed. took 81% as long as Ev. for the five-digit problems and 85% for the one-digit problems. F. took 80% as long as B. for the one digit and 83% for the five-digit problems, and P. in both cases approximated 50% of the time needed by C.

In the comparison of the figures given in Tables VIII, IX, and X, we are justified, I think, in considering that a large part of the time taken by Ed. at first for the five-digit problems was due to the retardation, and that much of his improvement was due to the recovery. Part of the improvement undoubtedly was due to practice. P. continued to show considerable speed in addition, and C. was consistently slow. The time of counting for P. was not proportionately so fast, but C's counting time was slow. Ev. also had slow counting time. Considering the time alone we might say that both C. and Ev. showed a retardation, but it was apparent that the slowing of C. was due rather to an awkwardness, and that Ev's was due to some retarding influence. C. showed throughout the experiments, as is indicated in all the tables, a decided mental and physical clumsiness which was not at all characteristic of Ev. The long average time taken by B. for the one hundred problems was due to the result of one experiment, in which some event must have occurred to greatly lengthen the time. On one day B. took 105 seconds for the test. If the other results be considered apart from this, we find an average time, 58.8 seconds, A. V., 3.0.

The difference in time between the addition and the counting may be taken as approximately the time of the mental operation of adding. This difference is large for C. and small for Ev. We also see that the results of the other subjects agree with each other quite well, and that there is a correspondence between these differences and the choice time (choice reaction time minus simple reaction time).

Ed. shows no retardation, in adding the one hundred problems, in counting, or in the adding time. Ev. is slow in adding and counting but the adding time is rapid. C. is slow in counting and much slower in adding, and his adding time is very slow. P. shows nothing abnormal.¹

¹ The averages for this experiment illustrate well the danger of drawing conclusions too hastily from time measurements of mental phenomena. The most evident conclusions from these results alone would be that C. was retarded at the time the experiments were made.

In the discrimination and distribution of one hundred colored cards results were obtained (Table XI) similar to some already discussed. Ev. was very slow, C. was slow, P. was medium in rapidity, and B., Ed., and F. were rapid, increasing in the order named. All the subjects improved from practice.

TABLE XI.

Weekly average time in seconds for discriminating and distributing one hundred colored cards. The average variations are given below the averages. The numbers of experiments, when more or less than five, are in parentheses.

| Serial weeks. | Normal. | | Depressed. | | Excited. | |
|---------------|----------------------|---------------------|---------------|---------------|----------------------|---------------------|
| | B. | F. | Ed. | Ev. | C. | P. |
| 1 | 157.5 7.5 (2) | 119.8 3.3 (4) | 151.0 20.8 | 422.6 30.1 | 201.0 21.3 (4) | 190.0 4.5 (4) |
| 2 | 133.8 7.8 (4) | 128.0 0.0 (1) | — | — | — | — |
| 3 | 141.5 14.5 (2) | — | — | — | — | — |
| 4 | 108.8 3.1 (6) | — | — | — | 188.2 7.8 | 134.8 5.9 |
| 5 | 105.2 2.6 | 109.0 4.7 (3) | 120.2 7.4 | 370.8 15.8 | — | — |
| 6 | — | — | — | — | 171.2 3.4 | 122.4 4.1 |
| 9 | — | 112.0 4.0 (2) | — | 376.8 25.4 | — | — |

Conclusions. When the results of all the experiments are considered it is evident that the excited patients do not show any consistent increase in speed over the normal or depressed patients. The maniacal condition is, therefore, not an increased motor ability but merely an increased motor diffusion.

The retarded subjects, on the other hand, were slow at the beginning of all the series, but this retardation in the time of mental processes is not regular.

For the performance of what we may call the more complex mental processes, *e. g.*, choice reactions, adding, etc., the retarded subjects do not take proportionately so long a time as they do for simpler acts. The maniacal patients tend to keep the normal relations.

In the retarded patients considerable practice effect was found. This was more noticeable during the first few experiments. In other work I have shown that general exercise increased the speed of some mental processes in a case of retardation, and at the same time lowered the thresholds for pain and touch sensations. These facts indicate that this class of patients may be improved to some extent by systematic exercise, *i. e.*, their movements may be made more rapid. This would not cure the depression but would help by lessening the retardation. In every person there is a tendency for the formation of habits, and not the least in the insane. It is probable that in many cases there is formed the habit of slowness, and this may be supplanted by an activity habit formed by exercise.

From the results of the simple reaction and the tapping experiments it seems unlikely that the retardation comes principally at the beginning of the movement, as has been suggested. If the retardation was a slowing in starting we should expect to have a definite time added to the normal time for all psycho-motor activities, and otherwise to keep the normal time relations (minus this time) for all mental processes. More detailed experiments are needed on this subject.

I have previously suggested that the retardation may be a general lowering of the irritability, but from the experiments already made it is not fully settled where the (supposed) lowered irritability is. Some experiments which I have made show that in cases of retardation the tendon reflexes are slower than normal and that the skin sensibility is dulled. In conjunction with the fact that the addition of extra mental processes does not greatly increase the total time, these facts would indicate that if there is a lowering of the irritability such lowered irritability is not principally in the brain but rather in the peripheral parts of the body, particularly the nervous system. I expect to take up this matter in more detail in another paper.

In only a few cases are the average variations for the insane subjects greater than normal.

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